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ABSTRACT

This paper discusses empirical findings from the first language acquisition of Mandarin Chinese suggesting that certain properties of the logical form of natural language are not learned from experience. These unlearnable properties appear to manifest themselves in the child's linguistic knowledge as soon as prerequisite conditions are met. Because of the inherent difficulties in the developmental study of quantification, the child language data reported does not confirm the innateness of the logical form properties at issue in a direct way. The evidence, however, is indicative of early acquisition of these linguistic properties, which are undetermined by the data the child is exposed to. The study is intended as a contribution to the study of linguistic universals. It was conceived on the assumptions of generative grammar and begins by placing itself in the broader context of the Chomskyan theory of linguistic universals. (Author/JL)

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The Learnability of Locality Conditions on Quantification[1]

Thomas Hun-tak Lee
Chinese University of Hong Kong

0. Introduction

In this paper, I will discuss empirical findings from the first language acquisition of Mandarin Chinese suggesting that certain properties of the logical form of natural language are not learned from experience. These unlearnable properties appear to manifest themselves in the child's linguistic knowledge as soon as prerequisite conditions are met.

Because of inherent difficulties in the developmental study of quantification, the child langauge data I am reporting will not confirm the innateness of the logical form properties at issue in a direct way. The evidence, however, is highly indicative of early acquisition of these linguistic properties, which are underdetermined by the data the child is exposed to.

This study is intended as a contribution to the study of linguistic universals. As it was conceived on the assumptions of generative grammar, I would like to begin by placing the study in the broader context of the Chomskyan theory of linguistic universals.

1. Chomsky's view of linguistic universals

The potential epistemological significance of Chomskyan linguistics lies in the rich array of concrete candidates for linguistic universals it has proposed in the past thirty years. The universals actively pursued in the paradigm are universals in a specific sense. They are principles that partially characterize the innate mental structures of the individual; they constitute the initial state of the linguistic component of the mind. These universals may also be thought of as representations of biological properties of the brain at some level of abstraction (Chomsky 1980:31, 1986:23, 1988:7-8).

The postulation of linguistic universals is necessitated by consideration of the disparate gap between the wealth and complexity of the individual's linguistic knowledge on the one hand, and the poverty of the data the individual has access to in the course of his language development. Only by imputing to the child a rich innate mechanism can language acquisition be explicable.

Further, these universals are assumed to be specific to the linguistic faculty of the mind, and may not be derivable from principles of other

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[1]An earlier version of this paper was read at the Conference on Analytic Philosophy & Linguistic Philosophy held at the Chinese University of Hong Kong on March 7-12, 1991. I am indebted to Norman Freeman, Steve Matthews and Virginia Yip for valuable comments on the earlier draft. Needless to say, the faults that remain are mine.

cognitive domains. For example, while some principle may underlie the human ability to arrange an array of hollow boxes according to size, so that smaller boxes are contained within larger ones, cognitive principles such as this may not have a direct link to seemingly parallel linguistic capacities such as the ability to embed a phrase within another. [2]This emphasis on the language-specific nature of universals is a central feature of Chomsky's conception of universals, and distinguishes it from alternative theories such as those proposed by Piaget (see Piaget & Inhelder 1969, Piatelli-Palmarini 1980).

Given these biologically endowed linguistic principles, language acquisition may proceed in a highly deterministic manner, using the minimal information provided by experience. 'Knowledge of language' is thus said to 'grow in the brain'; it just 'happens to us'.[3] Acquiring the grammar of a language is seen as a process of setting the parameters stated in terms of the linguistic universals. The values of the parameters are set on the basis of data from the particular language concerned. The process can be likened to the setting of switch positions on a battery, so that each combination of settings will yield the core grammatical properties of a natural language (cf. Chomsky 1986:146). Examples of these parameters that have emerged in the literature include the relative order of the head to the other constituents in the phrase (the word order parameter, cf. Stowell 1981)); the possibility for non-overt noun phrases to occur in subject position of finite clauses in languages such as in Chinese or Italian (the pro-drop parameter, cf. Hyams 1986); differences in the scope of the domains in which the Binding Principles of Chomsky (1981) hold (the Governing Category Parameter, cf. Manzini & Wexler 1987).

In this view, linguistic universals are not necessarily properties common to all languages. In fact, properties common to all languages may have only accidental interest if they can be acquired from exposure to language data. For example, while the hierarchical structure of sentences cannot be learned from experience, the possibility that all languages have words for 'sun' and 'moon' can be accounted for by the presence of these planets in the experience of all speech communities. The former will count as a candidate for a linguistic universal, whereas the latter is of trivial

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[2] See Greenfield (1978) for a illustrative example of an experimental attempt to establish parallels between general cognitive abilities and linguistic competence.

[3] 'knowledge of language' here means tacit knowledge of language. It is assumed that speakers have internalized in their brain a grammar of their language. Such knowledge can be demonstrated in the form of speaker judgments of ambiguity and anomaly of sentences as well as paraphrase or inconsistency relations of sentences. I will not go into the criteria for establishing knowledge such as those proposed in the literature, e.g. recognition and justification (cf. Nagel 1974). Nor will I explore rival views on the mental grammar (cf. the Platonist conceptions of Katz 1981). In any case, whether one accepts these regularities as mental representations of the speaker should not affect the substance of the empirical findings in this paper.

interest.

Nor is it the case that linguistic properties present in the initial state of the individual are immutable and cannot be changed in the course of development. Such changes are permissible as long as the data encountered by the child are sufficiently rich to warrant such alterations.

Consider the well known fact that a constituent within a relative clause modifying a noun cannot be questioned for a variety of languages (cf. Ross 1967). This is attributed to a constraint known as the Complex Noun Phrase Constraint (CNPC). Thus a contrast may be observed between (1a-b) and (1c-d). Corresponding to a sentence such as (1a), one may have a question such as (1b) in which the object of the preposition "on" is questioned. However, the object of the same preposition in (1c), which is contained within the complex noun phrase "a dog who is gnawing on..." cannot be questioned, as can be seen from the ungrammaticality of (1d).

(1a) The dog is gnawing on a bone.
(1b) What is the dog gnawing on __?
(1c) I see a dog [who is gnawing on a bone].
(1d) *What do I see a dog [who is gnawing on ___]?

The CNPC does not appear to be a linguistic property learned from experience. If children were to induce this from the languge data they are exposed to, they would need to have access not only to sentences such as (1b), but also information about the ungrammaticality of sentences like (1d). Given the fact that negative data (i.e. data informing the learner that certain sentences of the language are ungrammatical) are generally absent from normal language acquisition, this scenario seems unlikely. Experimental studies carried out with English-speaking children (cf. Otsu 1981) have also demonstrated early sensitivity to the CNPC

While assumption of a condition like the CNPC may be part of the initial language learning apparatus of the child, these initial assumptions can be revised if the data available to the child contradict them. In this connection, it should be noted that the Swedish counterpart of (1d), given in (1e), is said to be grammatical (Allwood 1982:17).

(1e)	Vad	ser	jag	en	hund	som	gnager	pa?
	what	see	I	a	dog	who	is-gnawing	on

"What do I see a dog who is gnawing on?"

In such a case, one might still posit the impossibility of questioning something within a relative clause as an innate given. Speakers of Swedish are special in that positive evidence from their language will lead them to revise this initial assumption about the possibilities of questioning, whereas such revision will not be necessary for speakers of other languages.

2. Locality Principles as a type of linguistic universal

The linguistic universals germane to the present study are constraints similar to the CNPC, which govern the well-formedness of linguistic representations at particular levels of grammar. These constraints are also known as locality principles. Essentially, locality principles require that elements moved from a particular position must not be too distant from the

latter. The relationship between the moved element and the position left behind must be in some sense 'local'.

The example below illustrates another locality condition on syntax besides the CNPC. This constraint, known as the wh-island condition, prohibits a question phrase from moving outside an interrogative complement of a clause.

(3) John wondered [*what* Mary bought _].
(4) **What* did John wonder [who bought _]?

Assume that the above sentences are derived by moving the wh-phrase *what* from the object position of *bought* in the complement clause of *wonder*. While *what* can move to the initial position of the complement clause in (3), it cannot go beyond the interrogative complement to the initial position of the main clause in (4).

As explained in the preceding section, these locality constraints cannot be learned from experience, because the language data are too impoverished to allow for induction of the relevant principles.

3. Locality Principles on Logical Form

Locality principles have also been proposed for the level of Logical Form (LF). Before we look at these principles, a characterization of this level of LF is in order. In the current version of syntactic theory known as Government Binding theory (GB), the level of LF is defined by the rule of Quantifier Raising (QR), which attaches quantificational NPs such as *every N, a N, two N* to an S node of the sentence (May 1977, 1986). Thus, corresponding to (5) below, the LF representations are (5a) and (5b) respectively.

(5) *Every child* sits on *a plate*.
(5a) [*Every child*$_x$ [*a plate*$_y$ [x sits on y]]
(5b) [*A plate*$_y$ [*every child*$_x$ [x sits on y]]

(5a) gives the reading in which *every child* has scope over *a plate*: for every child there is a plate such that he sits on it; different children may sit on different plates. On the other hand, (5b) gives the interpretation in which *a plate* has scope over *every child*: there is a plate such that every child sits on it. The level of LF in GB can be seen as a level of representation in which scope ambiguity of Quantifier phrases is primarily resolved structurally. The LF representations are derived from surface structures via non-overt movement.[4]

A strong argument for the postulation of LF is the striking parallels

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[4]Alternative formulations of quantifier scope are of course possible. For example, scope ambiguity is not represented configurationally but procedurally in Montague semantics (see Dowty, Wall and Peters 1981). Again the phenomenon of relative scope and clauseboundeness of scope must be acknowledged irrespective of the theoretical apparatus one uses to capture them.

between overt movement in syntax (from D-structure to S-structure) and non-overt movement in LF (from S-structure to LF representation). Thus, for example, just as a wh-phrase cannot be coreferential with a pronoun it crosses in syntax, so a quantifier phrase such as *everyone* cannot bind a pronoun it crosses in LF.

Consider the difference between (6a) and (6b). The former can be understood with the pronoun *he* functioning as a bound variable, as in (6c). However, the bound variable reading of the pronoun in (6b), as given in (6d), is not well-formed. The impossibility of a bound variable reading in (6b) correlates with the movement of the wh-phrase over a pronoun in the sentence.

(6a) *Who*$_i$ betrayed [the woman *he*$_i$ loved]?
(6b) **Who*$_i$ did [the woman *he*$_i$ loved] betray _ ?
(6c) For which x=person, x betrayed the woman x loved.
(6d) *For which x=person, the woman x loved betrayed x.

A parallel distinction can be observed in the pair of sentences (7a-b). (7a) can be interpreted with the pronoun serving as a bound variable, as indicated in (7c). However, this interpretation is ruled out for (7b), as evidenced by the ill-formed representation in (7d).

(7a) *Everyone*$_i$ betrayed [the woman *he*$_i$ loved].
(7b) *[The woman *he*$_i$ loved] betrayed *everyone*$_i$.
(7c) For all x=person, x betrayed the woman x loved.
(7d) *For all x=person, the woman x loved betrayed x.

This parallel may be captured if one conceives of a movement process such as Quantifier Raising in the mapping between S-structure and LF. Viewed this way, movement of the wh-phrase in syntax in (6a) and movement of *everyone* in LF in (7a) do not involve crossing of the pronoun *he*. Therefore, the latter can be understood as a variable bound by the respective quantificational elements. In contrast, such movement in (6b) and (7b) involves crossing the pronoun. Thus *he* cannot be interpreted as a bound variable in these sentences (Chomsky 1976, 1980).

Another striking parallel between syntax and LF concerns the locality conditions. Just as a phrase cannot be moved from inside a relative clause to a non-local position in syntax, so a quantifier phrase cannot be raised beyond the complex noun phrase containing the relative clause in LF (cf. Rodman 1976, May 1977, Hornstein 1984).

(8) The cake [that *every child* is eating] sits on *a plate*.
(8a) [*A plate*$_y$ [the cake [that *every child*$_x$ [x is eating]]] sits on y]
(8b) *[*Every child*$_x$ [*a plate*$_y$ [the cake [that x is eating]] sits on y]]

(9)	[*meige*	*xiaohai*	dou	zai	chi]	de	dangao	fang	zai	*yige*	*diezi*	shang
	every	child	all	ASP	eat	NOM	cake	put	at	one	plate	on

(ASP=aspect marker; NOM=nominalizer)

Unlike *every child* in (5), the effect of the universal quantifier in (8) cannot extend beyond the relative clause to have scope over the existential quantifier in the main clause. Thus while one may understand the sentence as meaning "there is a plate such that the cake that is being eaten by every

child sits on it", one cannot take the sentence to mean "for every child x, there is a plate such that the cake that x is eating sits on it." In other words, (8a) is a legitimate LF representation, but not (8b). In (9), the Chinese counterpart of (8), the same facts obtain. The universal quantifier in the relative clause *meige xiaohai* 'every child' cannot take scope over the existential quantifier in the main clause *yige diezi* 'a plate'.[5]

We assume that this locality condition on quantifier interpretation is unlearnable and may be hypothesized as one of the linguistic properties that characterize the initial state of the individual. If this is true, one may expect this property to manifest itself as soon as the learner is capable of coping with complex structures of the type illustrated by (8-9).

4. Acquisition of LF properties

What kind of knowledge is required of the child to interpret sentences such as (5) and (8-9) correctly? At least three kinds of knowledge are necessary. First, the child must have some means of representing the relative scope of quantificational elements such as wh-phrases and quantifier noun phrases. In our framework, this is captured by the rule of Quantifier Raising. Second, the learner must know the principles for interpreting the relative scope of quantificational elements for his/her particular language. Languages may differ in their scope interpretation principles. For instance, a language like English does not base scope relations uniquely on the relative position of quantificational elements at surface structure. Thus sentences like (5) and (10) allow either of the quantifier phrases to take scope over the other. However, in languages such as Chinese, scope relations are in most cases uniquely mapped from surface structure properties (Xu and Lee 1989). Thus the Chinese counterpart of (10), given as (11), is unambiguous with only the wide scope reading of the existential quantifier.

(10) *A child* sits on *every plate*.
(10a) [*A child*$_x$ [*every plate*$_y$ [x sits on y]]
(10b) [*Every plate*$_y$ [*a child*$_x$ [x sits on y]]

(11) (you)	*yige*	*xiaohai*	zuo	zai	*meige*	*diezi*	shang
(exist)	one	child	sit	at	every	plate	on

"A child sits on every plate"

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[5]It has been observed (cf. Farkas 1981, Hornstein 1984) that the locality conditions governing quantifier interpretation in sentences such as (8b) are not identical to the CNPC. A tensed clause is sufficient to establish an opaque domain for universal quantifiers. Thus, the sentence below cannot be understood with *everyone* having scope over *a girl*.

(a) *A girl* said [that *everyone* should attend the party].

In this paper, while discussion of locality conditions will center around sentences with quantifiers embedded in relative clauses, we shall assume that it is the tensed clause that is blocks quantification.

In order for children to properly interpret relative scope in a particular language, they need to establish these language-specific scope principles at some point in their language acquisition. Thirdly, children need to be equipped with knowledge of unlearnable conditions such as the clauseboundedness constraint on quantification illustrated in (8-9).

Various accounts have been proposed to address the question how variable binding operations are acquired. A well known proposal is the essentially behaviorist explanation given by Quine (1974), who attributes the source of knowledge of variables to categorial sentences of the form "Every A is B" and "An A is B" and substitutional quantification in relative clauses. Another proposal (Hornstein 1984) considers the possibility that children start out by assuming all noun phrases to be quantifiers. Empirical investigations have been conducted on the scope principles children use to interpret relative scope in different languages (Lee 1986, in press, Chien and Wexler 1989). The experimental findings I am reporting here relate to the third issue: to what extent do young children observe the locality conditions on logical form?

5. Experiment on Clauseboundedness of Quantification

5.1 Procedure and subjects

The purpose of the experiment was to see if Chinese children's interpretation of the relative scope of quantifier phrases observes the clauseboundedness constraint on quantification. A picture identification task and an act-out task related to quantification were carried out on 61 Mandarin-speaking children and 12 adults in Beijing. There were 12 four-, five-, six- and eight-year-olds, and 13 seven-year-olds. As a separate experiment, another act-out task testing the subjects' understanding of sentences containing relative clauses was also administered (cf. Lee to appear). Care was taken to ensure that half of the subjects in each age group fell into the first six months of the age, while the other half of the group belonged to the latter six months.

For the quantification study reported here, each child subject was interviewed by two experimenters for around 30 minutes. Test sentences were recorded on an audiotape, which was played to the child. In the picture identification task, the child was asked to point at one of two pictures according to his/her understanding of a test sentence (cf. Fig. 1). In the act-out task, the child was asked to manipulate toy objects according to his/her understanding of a test sentence (cf. Fig. 2).

5.2 Test Sentences

The purpose of the experiment necessitates the use of two quantifiers in separate clauses, and therefore the use of complex sentences. The test sentences used were left-branching structures with the subject of the main

clause modified by a relative clause, as in (12-15).[6]

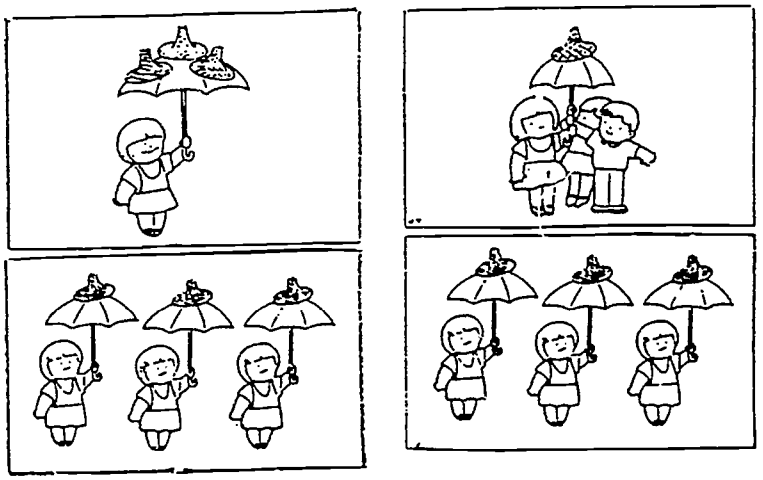

Fig. 1(a) Fig. 1(b)

Fig. 1 Pictures for Picture Identification Task

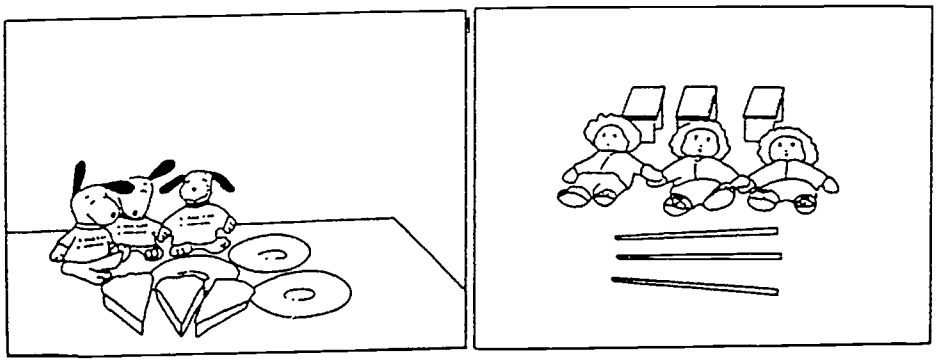

Fig. 2(a) Fig. 2(b)

Fig. 2 Prop Settings for Act-Out Task

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[6]In theory, a more direct test of the clauseboundedness constraint on quantification is to use test sentences involving simple verbal complements, such as (a) in the preceding footnote. However, these sentences generally involve verbs of communication in the main clause. This makes it extremely difficult to design act out tasks.

Representative test sentences for picture identification (cf. Fig. 1)

(12a) [_ nazhe *meiba yusan*] de xiaohai zhan zai *yige dengzi* shang
carry every umbrella NOM child stand at one stool on
"The child [who is carrying every umbrella] is standing on a stool"
[Type I, AE order]

(12b) [_ nazhe *yiba yusan*] de xiaohai zhan zai *meige dengzi* shang
carry one umbrella NOM child stand at every stool on
"The child [who is carrying an umbrella] is standing on every stool"
[Type I, EA order]

(13a) [*meige ren* dou nazhe_] de yusan dingzhe *yiding maozi*
every person all carry NOM umbrella support one hat
"The umbrella [that everyone is carrying] is supporting a hat"
[Type II, AE order]

(13b) [*yige ren* nazhe_] de yusan dingzhe *meiding maozi*
one person carry NOM umbrella support every hat
"The umbrella [that someone is carrying] is supporting every hat"
[Type II, EA order]

Representative test sentences for act-out (cf. Fig. 2)

(14a) [_ nazhe *meige kuaizi*] de xiaohai zhan zai *yige dengzi* shang
carry every chopstick NOM child stand at one stool on
"The child [who is carrying every chopstick] is standing on a stool"
[Type I, AE order]

(14b) [_ nazhe *yige kuaizi*] de xiaohai zhan zai *meige dengzi* shang
carry one chopstick NOM child stand at every stool on
"The child [who is carrying a chopstick] is standing on every stool"
[Type I, EA order]

(15a) [*meige xiaogou* dou zai chi] de dangao fang zai *yige diezi* shang
every puppy all ASP eat NOM cake put at one plate on
"The cake [that every puppy is eating] is put on a plate"
[Type II, AE order]

(15b) [*yige xiaogou* zai chi] de dangao fang zai *meige diezi* shang
one puppy ASP eat NOM cake put at every plate on
"The cake [that a puppy is eating] is put on every plate"
[Type II, EA order]

Several remarks are in order about the design of the test sentences. First of all, it should be observed that in (12) and (14), the subject of the main clause also functions as the subject in the relative clause. These will be referred to as Type I sentences. However, in (13) and (15), the subject of the main clause functions as the object of the relative clause. These sentences will be called Type II sentences. Because of this, the quantifier phrase within the relative clause appears in object position in Type I sentences, but in subject position in Type II sentences.

Secondly, as can be seen from the test sentences, corresponding to each relative clause structure (e.g. (12, 14) vs (13, 15)), two quantifier orderings were used, one with the universal quantifier in the relative clause and the existential quantifier in the main clause (henceforth referred to as the AE order), another with the existential quantifier in the relative clause and the universal quantifier in the main clause (henceforth EA order). Two

test sentences were used for each combination of relative structure and quantifier ordering, yielding a total of 8 test sentences for either of the two tasks. In sum, a total of 16 test sentences were used for the data reported here.

5.3 Possible interpretations of the test sentences

To determine whether the child obeys the locality condition on quantification in interpreting the test sentences, two preconditions must be met. One is that the child must interpret the test sentences as complex sentences. If the child were to reanalyze these sentences as having a different structure, then their responses will not be reliable indicators of adherence to or violation of the locality constraints.

Secondly, one has to ensure that the child is interpreting the quantifier phrases as quantifiers and not referring expressions. This point is particularly pertinent to the child's interpretation of indefinite noun phrase of the form *a N*. These noun phrases may be interpreted as quantificational elements, in which case they function as existential quantifiers. At the same time, they may be understood referentially, in which case they are not quantifiers but referring expressions. In the latter situation, the data will not bear on the issues being investigated.

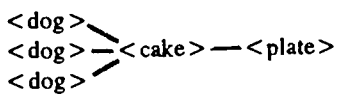

Fig. 3(a) singular bounded reading

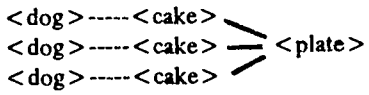

Fig. 3(b) plural bounded reading

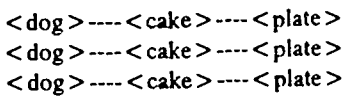

Fig. 3(c) *unbounded reading

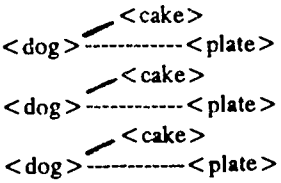

Fig. 3(d) conjoined reading

Fig. 3 Possible interpretations of a Type II test sentence with AE order:
[*meige xiaogou* dou zai chi] de dangao fang zai *yige diezi* shang
every puppy all ASP eat NOM cake put at one plate on
"The cake [that every puppy is eating] is put on a plate"

Because of the above considerations, it is argued that the crucial data for our analysis should come from sentences of the AE order, ie. the (a) sentences of (12-15) in which the universal quantifier resides in the relative clause and the existential quantifier in the main clause. In contrast, as I will explain below, the (b) sentences of (12-15) will not provide useful information about the issue being investigated.

How will children interpret a sentence such as (15a)? Their interpretation will depend on the structural description they assign to it. Assuming the child correctly assigns the relative clause structure to (15a),

we may have the interpretations diagrammed in Fig. 3(a) and Fig. 3(b) both of which are consistent with the locality condition. The child may assign a reading in which he interprets the subject of the sentence *dangao* 'cake' as a singular noun, in which case the sentence will be understood as 'a cake being eaten by all the puppies sits on a plate'. This will be called the 'singular bounded reading' of AE sentences. Alternatively the child may understand *dangao* 'cake' as a plural noun, in which case the sentence will be interpreted as 'the group of cakes being eaten by the group consisting of all the puppies sits on a plate'. This will be referred to as the 'plural bounded reading' of AE sentences. Clearly, in both readings the universal quantifier is bounded by the relative clause.

If the child correctly interprets the syntactic structure of (15a) but violates clauseboundedness, then the response will be as in Fig. 3(c), in which corresponding to each puppy, the cake being eaten by it sits on a different plate. This unbounded reading will be the crucial piece of evidence for violation of the locality condition on logical form.

We have hitherto assumed that the child correctly interprets the sentence as one containing a relative clause. An added complication will arise if the child reinterprets the structure of (15a). If the nominalizer or relative clause marker *de* is ignored, it is possible to reanalyse the sentence as a conjoined structure, as in (16) below.

(16) *meige xiaogou* dou [zai chi dangao], [fang zai *yige diezi* shang]
every puppy all ASP eat cake put at one plate on
"Every puppy is eating a cake, (and) is put on a plate"

The response for such an analysis is diagrammed in Fig. 3(d), in which each puppy is eating a different cake and sitting on a different plate. Data such as this will not be relevant to this discussion because even if the universal quantifier takes wide scope, it does not do so by crossing a clausal boundary.

I will now explain why the (b) sentences of (12-15), that is the EA sentences in which the existential quantifier lies in the relative clause and the universal quantifier in the main clause, will not be informative with respect to the aims of our investigation. The possible responses of the subject to (15b) are diagrammed in Fig. 4.

The main problem in interpreting sentences of the EA order is that the reading predicted to be impossible by the locality constraint is logically equivalent to another reading in which *yige xiaogou* 'a dog' is interpreted referentially, as a particular dog. Both readings give the interpretation as in Fig. 4. If this phrase is understood as an existential quantifier, the unbounded reading of this quantifier taking scope over the universal quantifier in the main clause can be represented as Fig. 4(a) or Fig. 4(b). The former represents a singular reading of the subject of the main clause, *dangao* 'cake', while the latter a plural reading of the subject. However, both readings are also compatible with a referential interpretation of the indefinite noun phrase *yige xiaogou* 'a dog'. The referential interpretation will not be relevant to our investigation, since the indefinite noun phrase in this case will not be understood as a quantifier phrase. Thus, the EA sentences do not give unequivocal evidence of violation of the clauseboundedness constraint.

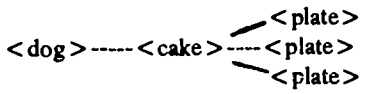

Fig. 4(a) singular referential reading
/*unbounded reading

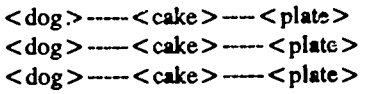

Fig. 4(b) wide scope reading of A

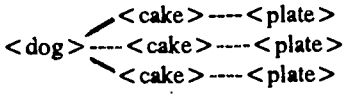

Fig. 4(c) plural referential reading
/*unbounded reading

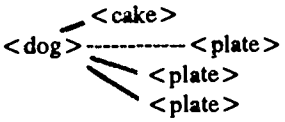

Fig. 4(d) conjoined reading

Fig. 4 Possible interpretations of a Type II test sentence with EA order:
[*yige xiaogou* zai chi] de dangao fang zai *meige diezi* shang
one puppy ASP eat NOM cake put at every plate on
"The cake [that some puppy is eating] is put on every plate"

The two remaining possible interpretations of (15b) are given in Fig. 4(b) and 4(d). The first represents the reading in which the universal quantifier in the main clause takes wide scope over the existential quantifier in the relative clause. Corresponding to every plate, there is a different cake being eaten by a different puppy. The second represents the reading in which the test sentence is reanalyzed as a conjoined structure, as in (17).

(17) *yige xiaogou* [zai chi dangao], [fang zai *meige diezi* shang]
one puppy ASP eat cake put at every plate on
"Some puppy is eating a cake (and) is put on every plate"

Either a referential reading or quantificational reading of *yige xiaogou* 'a puppy' will yield the situation in Fig. 4(d). This evidence again will not be shed light on observance or violation of clauseboundedness constraint.

In view of the above considerations, I will focus on the sentences with AE order in my presentation of the results and in my discussion.

5.4 Results on picture identification tasks

The results of the picture identification tasks on AE sentences are given in Tables 1 and 2. The responses on Type I sentences show that adults generally do not permit violation of the clauseboundedness constraint on any analysis. 83% of the adults gave a singular bounded reading; only one adult consistently gave an unbounded reading, while another wavered between a bounded reading on one test sentence, and an unbounded reading on another. The results on Type II sentences showed a slightly different picture, despite a similar tendency toward a bounded reading. 58% of the adults gave a singular bounded reading; 2 adults consistently gave an unbounded interpretation, while 3 others shifted between a bounded and an unbounded reading.

This discrepancy between the adult responses on the Type I and Type II sentences may be due to the possibility for reanalysis of Type II sentences as conjoined structures (cf. (16)), in which case the universal quantifier would not fall within a subordinate clause, and thus could take wide scope.

With regard to children's responses on Type I sentences, Table 1 shows that 75% of the four-year-olds chose the singular bounded reading. This figure dropped to 50% or slightly more for the five-, six-, and seven-year-olds, and climbed to 83% among the eight-year-olds. It should be observed at the same time that, with the exception of the seven-year-old group, there were extremely few consistent unbounded readings, the figure never exceeding 2 for any age group.

The picture looks somewhat different when we come to Type II sentences. As in the case of the adults, the children's responses on Type II sentences were more erratic. Only the four- and six-year-olds gave consistent bounded readings around 60% of the time. The figure for consistent singular bounded readings for the other age groups fluctuated between 15% and 33%. In contrast, between 33% and 62% of the five-, seven-, and eight-year-olds gave consistent unbounded readings, and between 25% and 33% of the child age groups varied between an unbounded reading and a bounded reading.

This more erratic pattern found in Type II sentences may be attributed to two factors. One is that Type II sentences could be reanalyzed as conjoined structures (cf. (16)). Secondly, once this reanalysis was carried out and a conjoined interpretation given, no picture was presented by the experimenter corresponding to the conjoined analysis. This may account for the relatively higher percentage of subjects in Table 2 rather than Table 1 who gave a bounded response on one test sentence and an unbounded response on another (see Column Four of the Table).

Table 1: Interpretation of AE sentences of the Type I form
[[_ V QNP_1] de N] V .. QNP_2 (Picture Identification)
A E

Example: [_ nazhe *meiba yusan*] de xiaohai zhan zai *yige dengzi* shang
carry every umbrella NOM child stand at one stool on
"The child [who is carrying every umbrella] is standing on a stool"

Age	singular bounded reading on both test sentences	unbounded reading on both test sentences	singular bounded/ unbounded reading on one test sentence
4 yr-old	9 (75%)	0	3 (25%)
5 yr-old	6 (50%)	2 (17%)	4 (33%)
6 yr-old	7 (58%)	0	5 (42%)
7 yr-old	7 (54%)	5 (38%)	1 (8%)
8 yr-old	10 (83%)	2 (17%)	0
Adult	10 (83%)	1 (8%)	1 (8%)

Table 2: Interpretation of AE sentences of the Type II form
[[QNP_1 V _] de N] V QNP_2 (Picture Identification)
A E

Example: [*meige ren* dou nazhe_] de yusan dingzhe *yiding maozi*
every person all carry NOM umbrella support one hat
"The umbrella [that everyone is carrying] is supporting a hat"

Age	singular bounded reading on both test sentences	unbounded reading on both test sentences	singular bounded/ unbounded reading on one test sentence
4 yr-old	8 (67%)	1 (8%)	3 (25%)
5 yr-old	2 (17%)	5 (42%)	5 (42%)
6 yr-old	7 (58%)	2 (17%)	3 (25%)
7 yr-old	2 (15%)	8 (62%)	3 (23%)
8 yr-old	4 (33%)	4 (33%)	4 (33%)
Adult	7 (58%)	2 (17%)	3 (25%)

5.5 Results on Act-out Tasks

The results on act-out tasks are more revealing, since the subject was not limited to a choice between two options. In the picture identification task, the subject had a 50% chance of hitting the right picture corresponding to the bounded or unbounded reading. The more open-ended nature of the act-out task would rule out this kind of random response. However, the act-out task had a different type of built-in bias. The fact that the subject was presented with three sets of objects, each with three members, may have favored an unbounded reading. We know from other experiments on quantification that children sometimes exhibit a tendency to match objects to produce a one-one correspondence (cf. Lee in press). In addition, if the child subjects were to rely heavily on pragmatic information, they might be reluctant to opt for readings for which some of the toys would be left undeployed.

Table 3: Interpretation of AE sentences of the Type I form
[[_ V QNP_1] de N] V .. QNP_2 (Act-out)
A E

Example: [_ nazhe *meige kuaizi*] de xiaohai zhan zai *yige dengzi* shang
carry every chopstick NOM child stand at one stool on
"The child [who is carrying every chopstick] is standing on a stool"

Age	singular bounded reading on both test sentences	unbounded reading on both test sentences	singular bounded/ unbounded reading on one test sentence	Special scope reading on one or both sentences
4 yr-old	1 (8%)	1 (8%)	0	10 (83%)
5 yr-old	0	6 (50%)	2 (17%)	4 (33%)
6 yr-old	4 (33%)	1 (8%)	2 (17%)	5 (42%)
7 yr-old	5 (39%)	3 (23%)	2 (15%)	3 (23%)
8 yr-old	9 (75%)	2 (17%)	0	1 (8%)
Adult	9 (75%)	0	0	3 (25%)

The results on act-out tasks are shown in Tables 3 and 4. In considering the adult responses on Type I sentences (see Table 3), we first note that there was absolutely no violation of the clauseboundedness condition. 75% of the adults consistently gave the singular bounded reading. The remaining adults gave special scope responses which (as we will see in Table 5) were all plural bounded readings. This means that 100% of the adults gave bounded readings on Type I sentences. Turning to Table 4, we see essentially the same picture: only 1 adult consistently gave an unbounded reading; 42% of the adults consistently responded with a singular bounded reading, while another 42% gave special scope responses that turned out to be (see Table 5) plural bounded readings. In other words, 84% of the adults gave bounded readings on Type II sentences.

Table 4: Interpretation of AE sentences of the Type II form
[[QNP_1 V _] de N] V QNP_2 (Act-out)
A E

Example: [*meige xiaogou* dou zai chi] de dangao fang zai *yige diezi* shang
every puppy all ASP eat NOM cake put at one plate on
"The cake [that every puppy is eating] is put on a plate"

Age	singular bounded reading on both test sentences	unbounded reading on both test sentences	singular bounded/ unbounded reading on one test sentence	Special scope reading on one or both sentences
4 yr-old	0	2 (17%)	0	10 (83%)
5 yr-old	0	8 (67%)	0	4 (33%)
6 yr-old	0	5 (42%)	0	7 (58%)
7 yr-old	0	6 (46%)	1 (8%)	6 (46%)
8 yr-old	0	3 (25%)	5 (42%)	4 (33%)
Adult	5 (42%)	1 (8%)	1 (8%)	5 (42%)

Turning to the child subjects, we observe from Table 3 a clear developmental trend in the percentage of singular bounded readings of Type I sentences. The figure started at 8% among the four-year-olds, but increased steadily to 39% among the seven-year-olds and 75% among the eight-year-olds. However, there were considerable violations of locality among the five-year-olds (50%) and seven-year-olds (23%).

The results on Type II sentences in Table 4 show even more consistent violations of clauseboundedness. It is striking to observe that none of the child subjects consistently gave singular bounded readings. In contrast, serious violations of locality (between 25% and 67% of the age group) can be seen in the responses of the five- through eight-year-olds.

Two factors may have been responsible for this high percentage of violation. One is, as I have mentioned earlier, the bias favoring matching of objects induced by the task and prop setting. Another factor may be the susceptibility of Type II sentences to reanalysis as conjoined structures, which would free these sentences from the constraints of locality.

The special scope responses are worthy of detailed attention, because herein lies important evidence for the clauseboundedness constraint. On

both Type I and Type II sentences, between around 30% and 83% of each age group showed special scope responses. To assess the significance of this pattern, we divided the special scope readings into three broad categories in Table 5: quantifier errors, plural bounded readings and conjoined readings.

Table 5: Classification of Special Scope readings on AE sentences.
Number of responses in different categories (Act-out only).

Age	AE sentences of Type I form				AE sentences of Type II form			% of total responses
	Quantifier errors			plural bounded reading	conjoined reading	Quantifier errors			plural bounded reading	conjoined reading	
	EE	AA	EA			EE	AA	EA			
4yr	7	3	3	0	0	7	1	4	1	2	53%
5yr	7	0	0	0	0	4	0	0	0	0	25%
6yr	6	0	0	0	0	2	1	0	0	6	32%
7yr	0	1	0	4	0	0	0	0	6	1	13%
8yr	0	0	0	3	0	0	0	0	5	0	9%
Adt	0	0	0	4	0	0	0	0	7	0	15%

A clear distribution of responses emerges from the table. For the four- to six-year-olds, the vast majority of the special scope responses were quantifier errors falling into one of three sub-types: either the young children reinterpreted the relationship between a universal quantifier phrase and an existential quantifier phrase as one between two existential quantifier phrases (EE), or as one between two universal quantifiers (AA), or they changed the ordering of the quantifier phrases from AE into EA. Fig. 5 illustrates the EE and AA quantifier errors corresponding to the AE sentence (15a).

Fig. 5(a) Fig. 5(b)

Fig. 5 Children's Quantifier Errors in Act-out Tasks

On the other hand, for the seven- and eight-year-olds and the adult group, all but one of the responses were plural bounded readings, which were consistent with the locality condition on logical form.

The fact that the special scope readings for the younger age groups were primarily errors in registering the quantifiers or errors in quantifier ordering suggests that this category of responses should not be taken as a mark of violation of clauseboundedness. The absence of quantifier errors among the 7-and 8-year-olds indicates that they were better able to handle the complexity of the task. In such circumstances, almost all the special scope responses of older children were plural bounded readings, reflecting adherence to the locality principle.

6. Discussion

To summarize the results presented above, on both Type I and Type II sentences and across task types, the majority of adults gave singular bounded readings, while some gave plural bounded readings. The general picture reflects consistent observance of the locality condition on quantificational scope.

The performance of the children varied noticeably according to the sentence type. Type I sentences reflected a generally low percentage of consistent locality violations on both kinds of tasks (cf. the percentage of consistent unbounded readings in Table 1 and Table 3). In addition, on act-out tasks, a clear developmental pattern in consistent singular bounded readings could be discerned (cf. Table 3).

Type II sentences, however, showed a much greater level of consistent unbounded readings. Given the bias toward an unbounded response in act-out tasks, and the fact that Type II sentences are more prone to be reanalyzed as conjoined structures with the universal quantifier in the main clause, data on Type I sentences should provide us with a firmer basis for analysis of the child's competence. Once we confine ourselves to Type I sentences, we find that except for some of the five- and seven-year-olds, the clauseboundedness constraint was observed by children and adults alike.

Table 6: Number of subjects who were 75% or more correct on Type I or Type II Sentence structure and differentiated between AE and EA order on simple clauses, but violated clauseboundedness

Age	Number of subjects	Sentence Type in which consistent violation occurred in Picture Identification	Sentence Type in which consistent violation occurred in Act-out	75% correct on Type I Sentence	75% correct on Type II Sentence
7yr-old	2	Type II		yes	yes
	1	Type II	Type I, Type II	yes	yes
	1	Type I,Type II		yes	yes
	1	Type I,Type II	Type II	yes	yes
8yr-old	1	Type II		yes	yes
	1		Type II	yes	yes
	1	Type I,Type II		yes	no
	1		Type I	yes	no
Adult	2	Type II		(yes	yes)
	1	Type I	Type II	(yes	yes)

The next question becomes: do the consistent unbounded readings reflect a genuine violation of locality? To answer this question, one would need to consider the prerequisites that have to be satisfied before one could be assured of a genuine violation. Specifically, the individual subject should (a) show understanding of the sentence structure in which the violation occurred (Type I and Type II), (b) demonstrate that s/he could differentiate

the AE and EA quantifier orderings, with clear attention paid to quantifier ordering, and (c) produce consistent unbounded readings. If all these features are observed in an individual subject, then one would have to think hard about his/her locality violations.

The child subjects who satisfied these conditions all turned out to be seven- or eight-year-olds. In addition, 3 adult subjects belonged to this category. The profile of consistent violations of these subjects is given in Table 6 below. I relied on results of a separate study which tested the same subjects' comprehension of sentences containing relative clauses (see Lee to appear) as a guide to their understanding of Type I and Type II sentences. A 75% level of correct comprehension was arbitrarily chosen. I also used the results of other tests for information about the same subjects' interpretation of universal and existential quantifiers in simple clauses (see Lee (in press) for details of the rationale).

As revealed in Column Two of Table 6, 5 seven-year-olds, 4 eight-year-olds, and 3 adults responded with genuine consistent unbounded readings, mostly on Type II sentences, and to a much lesser extent on Type I sentences. If we further restrict ourselves to Type I sentences, the group who consistently violated locality would be reduced to 3 seven-year-olds, 2 eight-year-olds, and 1 adult.

Why should these subjects, who consistently showed sensitivity to quantifier ordering, and who presumably should not have difficulty with the processing of Type I and Type II sentences, go for unbounded readings? I would like to suggest that these violations might have been incurred by the increased complexity of sentences containing relative clauses when the referring expressions in the clauses were replaced by quantifier phrases. In the experiments testing comprehension of relative clause sentences, only referring expressions were used as the arguments of the clauses. Therefore, even if subjects experienced no difficulty on these sentences, they might have found it difficult to process Type I and Type II sentences which contained quantifier phrases. In other words, the possibility remains that these subjects may not have attended to the structural and constituent cues despite an ability to do so. In so doing, they would have eliminated the subordinate clause and reanalyzed the sentence as a simple clause, making seemingly unbounded readings legitimate.

7. Conclusion

In this paper, we explored the issue whether the clauseboundedness condition on quantification is obeyed by Mandarin-speaking children. We have presented experimental evidence on how 4- to 8-year-olds interpreted complex sentences in which a quantifier phrase is embedded in a relative clause, while another is located in the main clause. We observed that to be able to examine children's knowledge of locality, we must make sure that the subjects are assigning the correct representation to the test sentences, and that they are not interpreting the indefinite NP as a referring expression.

These considerations have led us to identify sentences in which the universal quantifier sits in the object position of the relative clause (Type I sentences) as a reliable ground for observing children's comprehension of the quantified sentences.

Subjects' performance on Type I sentences in the picture identification

task suggests that half or more of the subjects in the various age groups consistently gave a singular bounded reading, reflecting adherance to the locality condition (cf. Table 1, column Two). Their performance on similar sentences in the act-out task shows that approximately one-third of the 6- and 7-year-olds, and 75% of the 8-year-olds gave a consistent singular bounded reading (cf. Table 3, column Two). Closer inspection of the various types of responses of the children reveals that the 4- to 6-year-olds experienced difficulty in coping with the complex test sentences. Many of the errors stemmed from either interpreting both quantifiers as existential quantifiers or universal quantifiers, or involved a reversal of the ordering of the quantifiers (cf. Table 5, columns Two to Four). Besides the singular bounded reading and the singular unbounded reading, a major type of response of the 7- and 8-year-olds was a plural bounded reading, which in fact conforms to the locality constraint. The data together point to a clear sensitivity to the clauseboundedness constraint on quantification among the 7- and 8-year-olds. Our analysis of the subjects' understanding of relative clause structure (given in Table 6) indicates that the somewhat irregular pattern of consistent bounded readings among the 4-, 5-, and 6- year-olds may be due to the complexity of the experimental task rather than to violation of locality principles. Future research with an improved experimental methodology may shed further light on this issue.

Our analysis thus far is by and large compatible with the assumption that clauseboundedness of quantification is an innate linguistic property, which should manifest itself in the linguistic behavior of individuals, so long as other prerequisites are satisfied and performance factors are abstracted away. This property is linguistic in character, since it makes reference to clausal boundaries in syntactic structure. It should be attributed to an innate mechanism, in view of the abstractness of such knowledge and the seeming impossibility of acquiring such knowledge on the basis of positive evidence. The overall empirical results of this study also indicate the presence of such knowledge in 7- and 8-year-olds, and perhaps in the younger age groups as well.

Disagreement will remain as to whether researchers would agree that this innate property should be counted as part of the individual's innate knowledge (cf. Quine 1972, Nagel 1974, D'Agostino 1986). Empirical research on the ontogenesis of grammar in the past three decades has produced a rich body of findings that bear on these issues. These results surely cast doubt on the sceptical remark of Quine (1972) that "Timely reflection on method and evidence should tend to stifle much of the talk of linguistic universals" (in Harman 1974:109).

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